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INVESTIGATION OF ICE DYNAMICS IN THE MARGINAL ICE ZONE  
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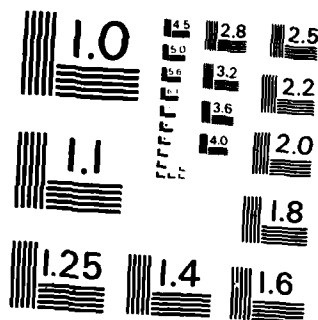
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INVESTIGATION OF ICE DYNAMICS IN THE MARGINAL ICE ZONE

Principal Investigator: Dr. Matti Leppäranta  
Contractor: Institute of Marine Research, Finland  
Contract Number: DAJA45-83-C-0034  
Third Periodic Report  
17 May - 15 September 1983

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THIRD INTERIM REPORT

Contract No. DAJA-83-C-0034 (82 December 22)

Contractor: Institute of Marine Research, Finland

Investigation of Ice Dynamics in the Marginal Ice Zone

Dr. Matti Leppäranta

Principal Investigator

The entitled work was commenced by the present writer on January 24, 1983, at the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL), Hanover, NH, and is done in cooperation with Dr. William D. Hibler III from CRREL. The work includes both a theoretical and an experimental part. After having given the second interim report (April 5, 1983), the main part of the work has been involved with the MIZEX (Marginal Ice Zone Experiment) field experiment in the Greenland Sea. Additionally, some advance has been made in the modeling studies of marginal ice zone dynamics.

Field Experiment

Dr. Hibler and the present writer participated in the MIZEX Greenland Sea Summer Pilot Study during June 9 to July 12 on the Norwegian ship Polarbjørn. The West-German icebreaker Polarstjern and the Norwegian oceanographic research vessel Lance also took part in the experiment, and detailed remote sensing studies were carried through which will give a good description of the general ice conditions around the research area. Further information of this pilot study is given in the plan for the MIZEX main summer experiment in 1984 (Johannessen et al. 1983).



*Letter on file*

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Polarbjørn sailed from Bergen, Norway, on June 10. The total of about 30 scientists were aboard, mainly from the USA and Norway. During the experiment the Arctic sea ice edge lay about zero meridian west of Svalbard and between the latitudes of  $80^{\circ}\text{N}$  and  $81^{\circ}\text{N}$  north of Svalbard (Fig. 1). Oceanographic instruments were first deployed in the Fram Strait. Then the research area was selected for the so-called drifting phase when our ice kinematics measurements were to be made. During this phase the ship was moored to an ice floe thus drifting with the ice. In the beginning the floe was situated at  $81^{\circ}03'\text{N}$   $6^{\circ}\text{E}$ , about 30 km from the ice edge (Fig. 1).

Our ice kinematics study was carried through using the Del Norte microwave trisponder system. In the spring, before the experiment, the system was tested at CRREL. It has been used earlier by CRREL scientists off the north coast of Alaska. Basically, the system consists of a master station, slave station and several remote stations (Fig. 2), in our case four remote stations were used. The direct distances from the master to the remotes and the range loops master-slave-remote-master are measured. One remote station was located at the same site as the slave station in order to get the baseline length which is needed for triangulation. As can be seen from Fig. 2, the three measurements for each remote give their positions in the coordinate system aligned with the baseline. That is, we can measure the strain-rate invariants with the system but naturally cannot get information of the rotation of our array in the earth coordinate system. This was measured using the

ship's gyrocompass and radar reflectors. The accuracy of Del Norte measurements is three meters which is far better than in the earlier observations of ice deformation in the marginal sea ice zones.

The drifting phase lasted from June 27 to July 8.. The Del Norte system worked well and the total length of gaps is less than ten percent in our time-series. They were mainly caused by delays in changing batteries in the remote stations when the weather was so foggy that the helicopters could not fly. The stations were mounted on the top of 3 m long pipes which stood with the help of rigid supports. These tripods, designed at CRREL, turned to be very good on soft summer ice. The ice conditions were almost ideal for our study. Ice concentration was seven to nine tenths around the research area and down to the ice edge. Horizontally the ice cover was very uniform with floe diameters typically around 50 meters. The ice pack was dominantly first-year ice and the amount of multi-year ice was 20-30%. The mean ice thickness was close to 2 m.

Polarbjørn drifted about 50 nautical miles northeast during the drifting phase. We obtained 11 days long time series with half-hour spacing. For about six days we sampled at 3-minute intervals. In the field we saw that the ice pack was often deforming at the rate of the order of 1% per hour which is one order of magnitude more than typically in the central Arctic Ocean. There seemed to be significant amount of energy in periods less than half an hour and it will be most interesting to analyze our high frequency data since this is the first such data ever recorded.

Over the whole period the deformation of the ice had a kind of back-and-forth nature, and the distances between the ship and the stations on the ice varied within 1-2 km. Examples of the array configuration are given in Fig. 3.

After the experiment the present writer has begun to analyze the observations. As a first step, raw and smoothed data files are under construction. During the next three months most of the time will be spent in working with the data.

#### Modeling Marginal Ice Zone Dynamics

Before the field experiment a report manuscript was written on the one-dimensional simulations described in the second interim report. A small study was also carried through considering analytical linear viscous solutions for idealized marginal ice zones. These results will be presented at a modeling workshop organized by Dr. Hibler in October 1983.

#### References

- Johannessen, O.M., W.D. Hibler III, P. Wadhams, W.J. Campbell, K. Hasselmann, I. Dyer, and M. Dunbar, 1983: MIZEX. A program for mesoscale air-ice-ocean interaction experiments in Arctic marginal ice zones. II. A plan for a summer marginal ice zone experiment in the Fram Strait/Greenland Sea: 1984. CRREL Report, May 1983.

*Matti Lepparanta*

MATTI LEPPARANTA

DET NORSKE METEOROLOGISKE INSTITUTT

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ISKART nr. 26/83, UTARBEIDET 28. JUNI 1983

Iskartet er tegnet ved satellittbilder fra 23.-27. juni 1983

Isobservasjoner 27. juni 1983

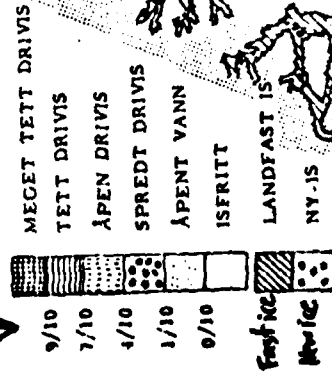
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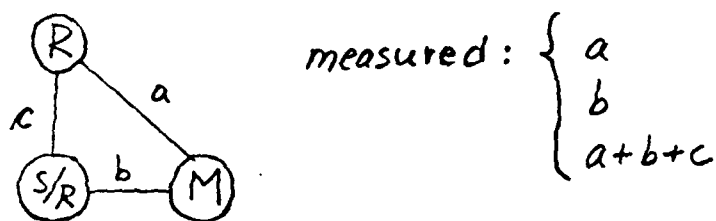
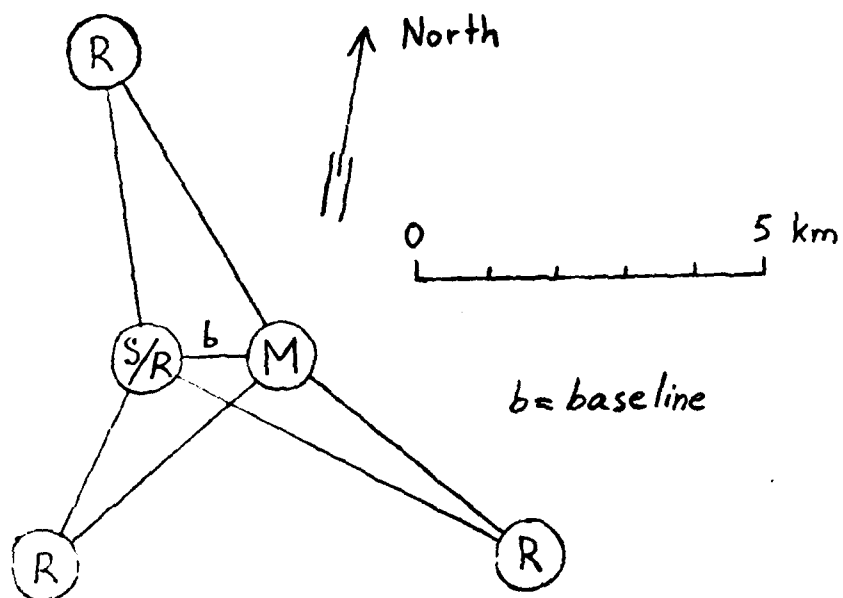
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Fig. 1. Ice conditions in the beginning of the drifting phase. The location of Polarbjørn is shown by ⊗.





M - master station (the ship)  
 S - slave station  
 R - remote station

Fig.2. Del Norte stations in the experiment.

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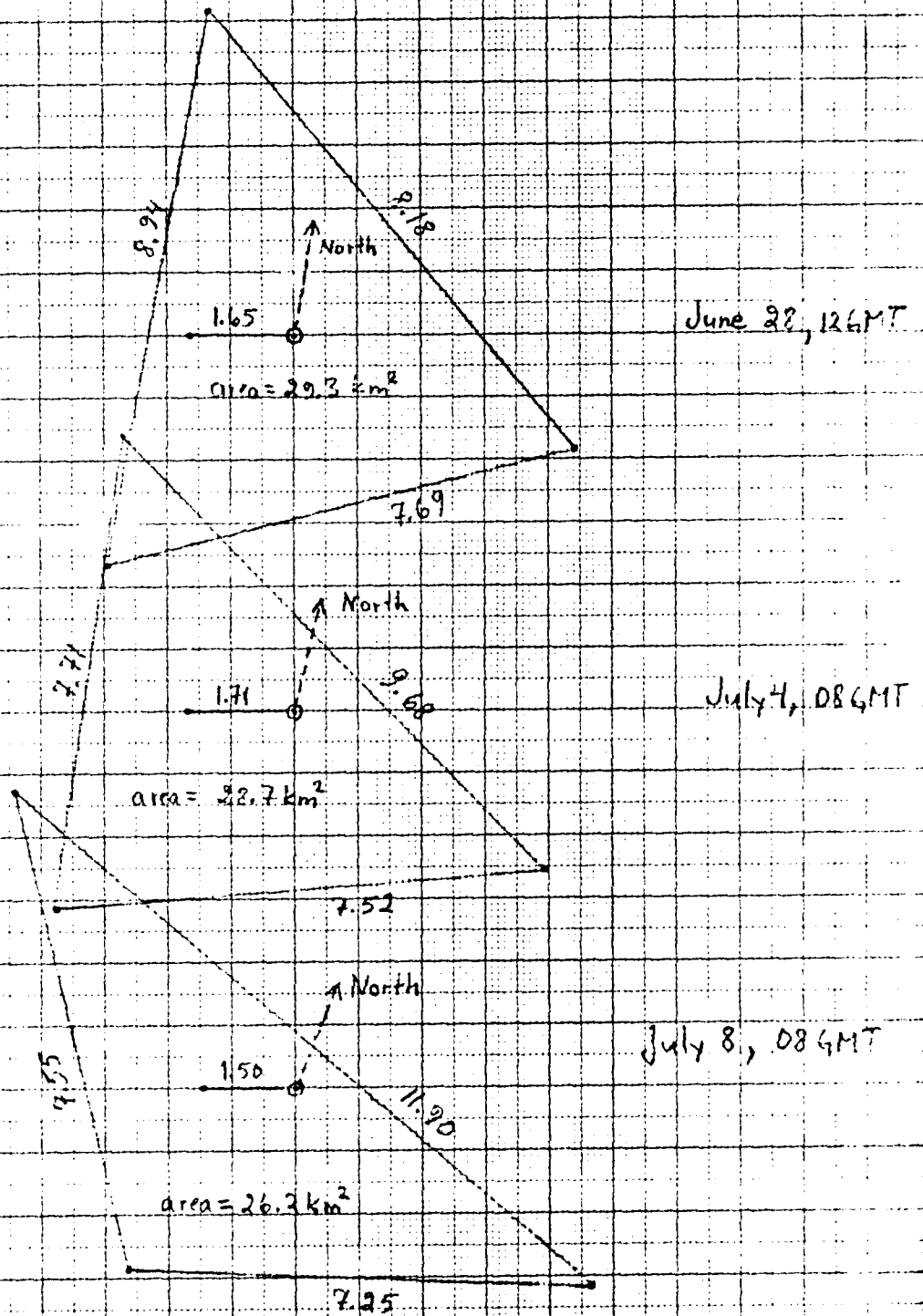


FIG. 3. Examples of the array configuration during the experiment. Lengths are given in km.

ANNEX

a. The amount of unused funds: none

b. Important property acquired: none